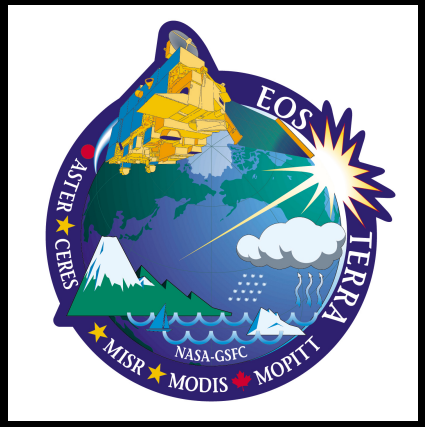
Comparing the relative stability of CERES, MISR and MODIS Radiances



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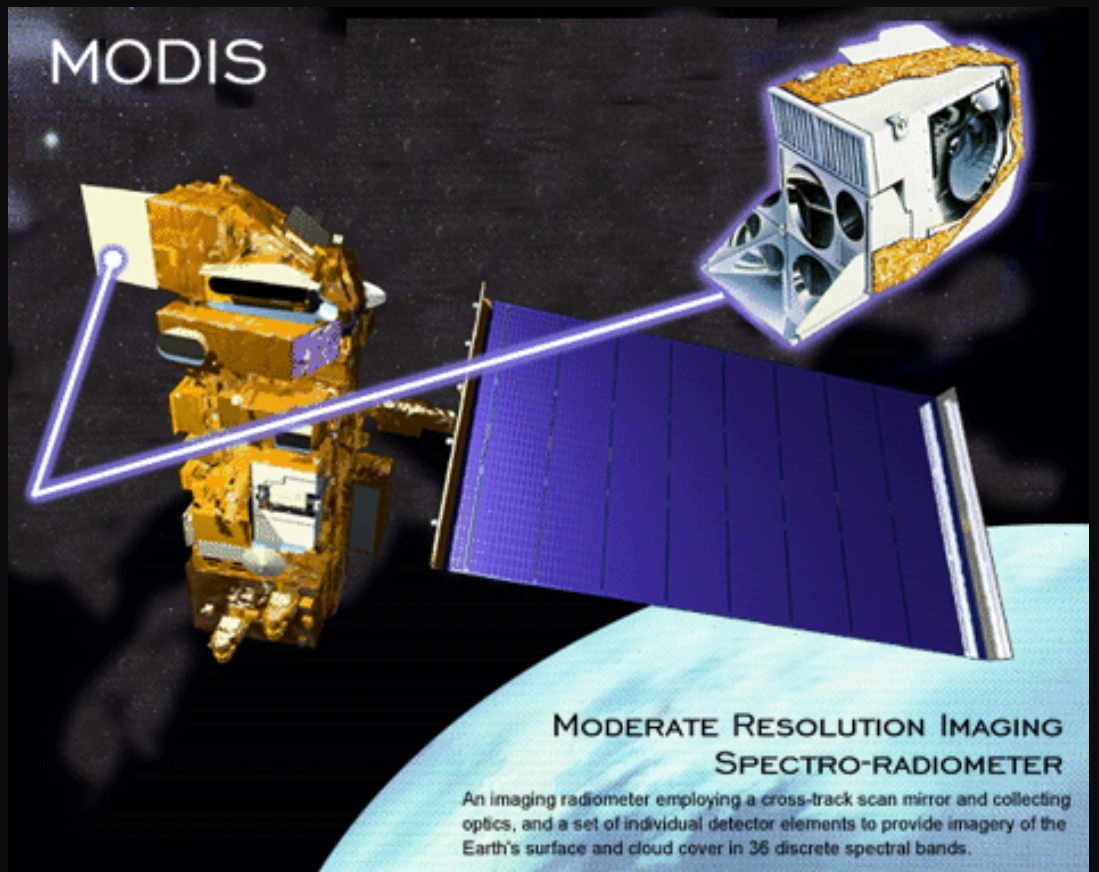
Introduction

- 14 year record of Terra allows us to compare the long-term relative stability of the radiances from the different instruments.
- We can use this to get a sense of the robustness of trends (or lack of trends as the case may be) in the reflected radiation.
- CERES, MISR and MODIS all have independent calibration techniques so comparing them is a good test of each instruments calibration.
- We use the Single Scanner Footprint - MISR (SSFM) dataset.
  - Combines CERES, MODIS and MISR radiances and scene information into a single dataset.

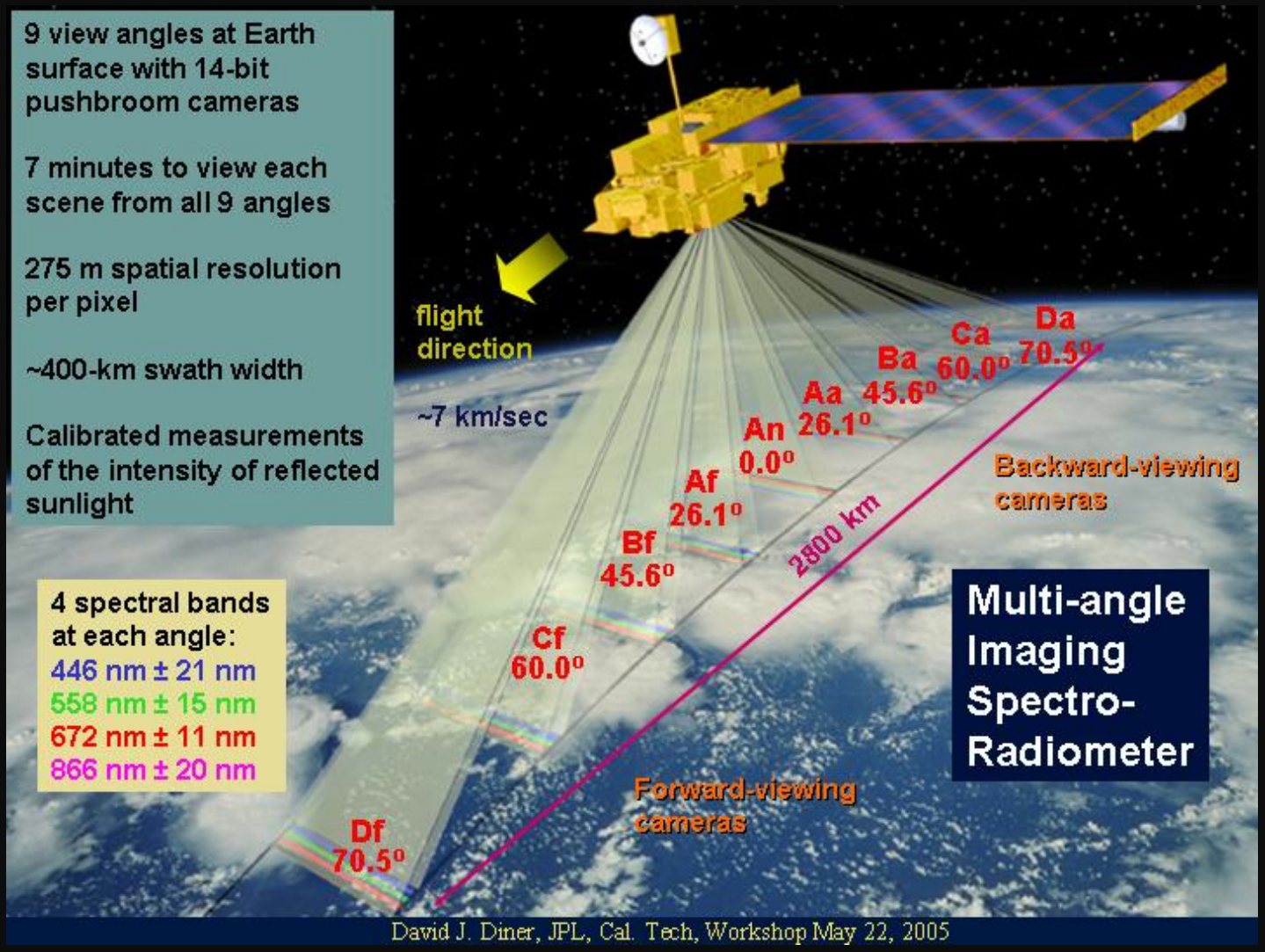
MODIS

- Moderate Resolution Imaging Spectrometer
- Scans across the satellite track
- 36 narrowband channels from ~0.4 microns to ~15 microns
- Spatial resolution between 250m and 1000m



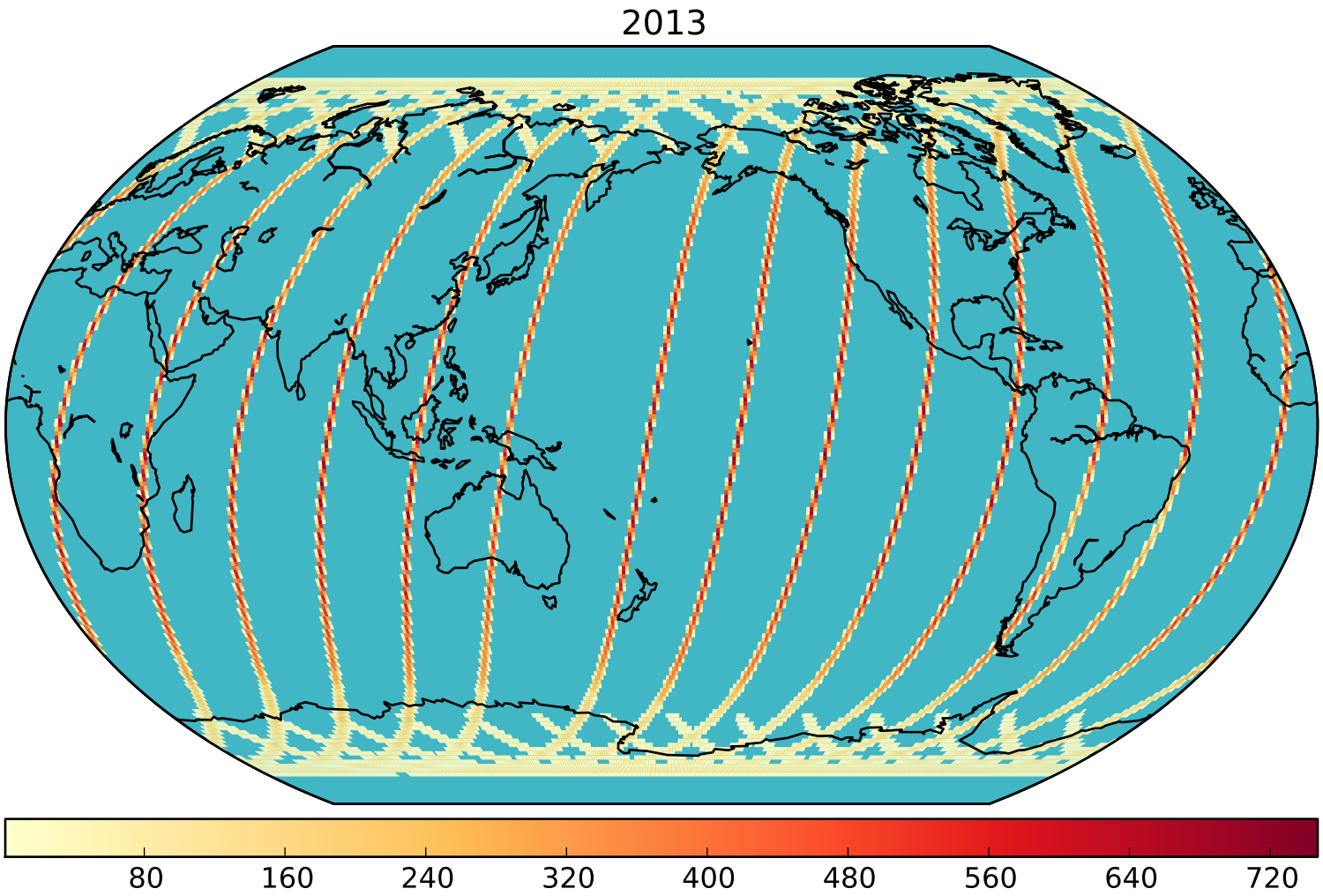
MISR

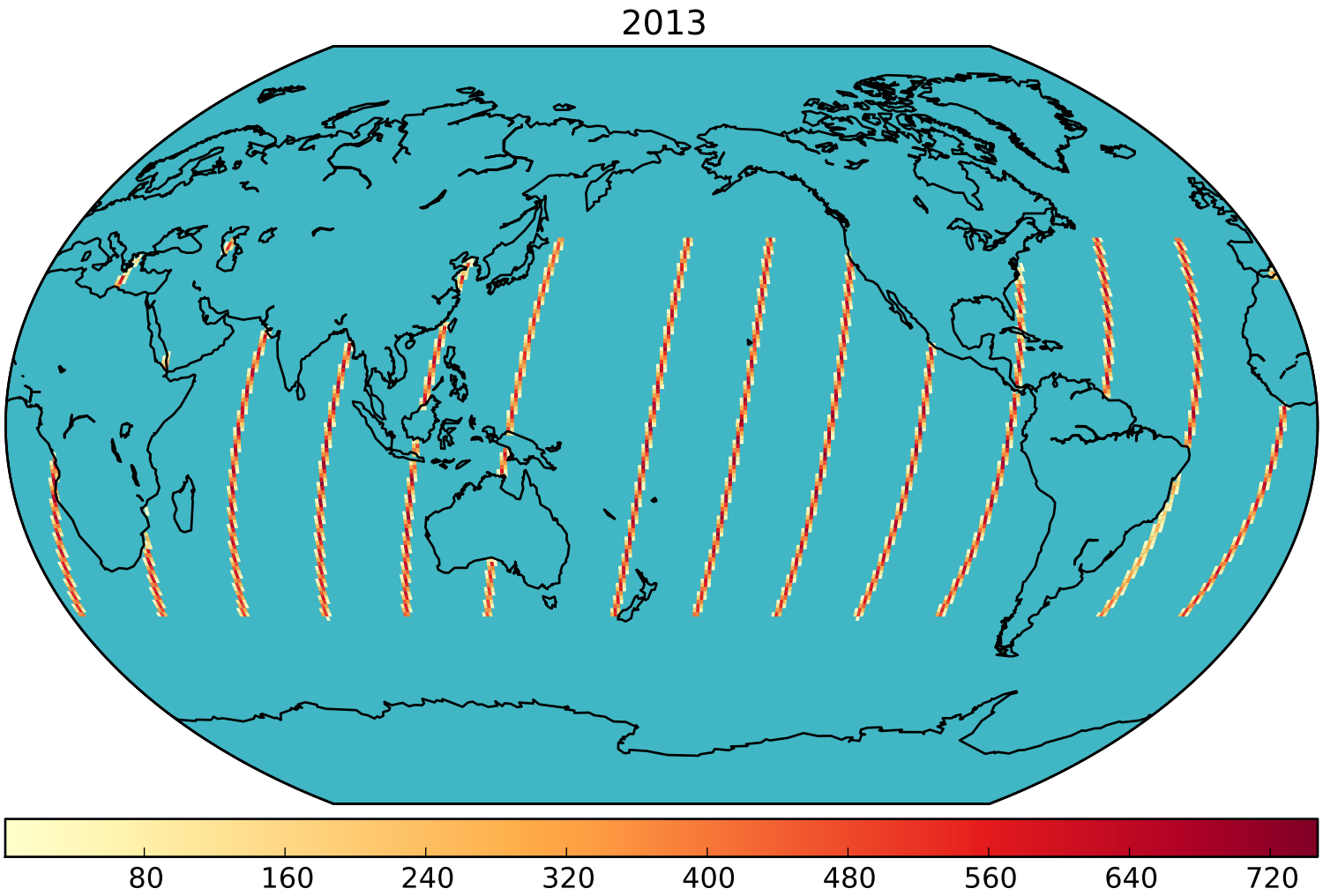
- Multi-angle Imaging Spectro-Radiometer

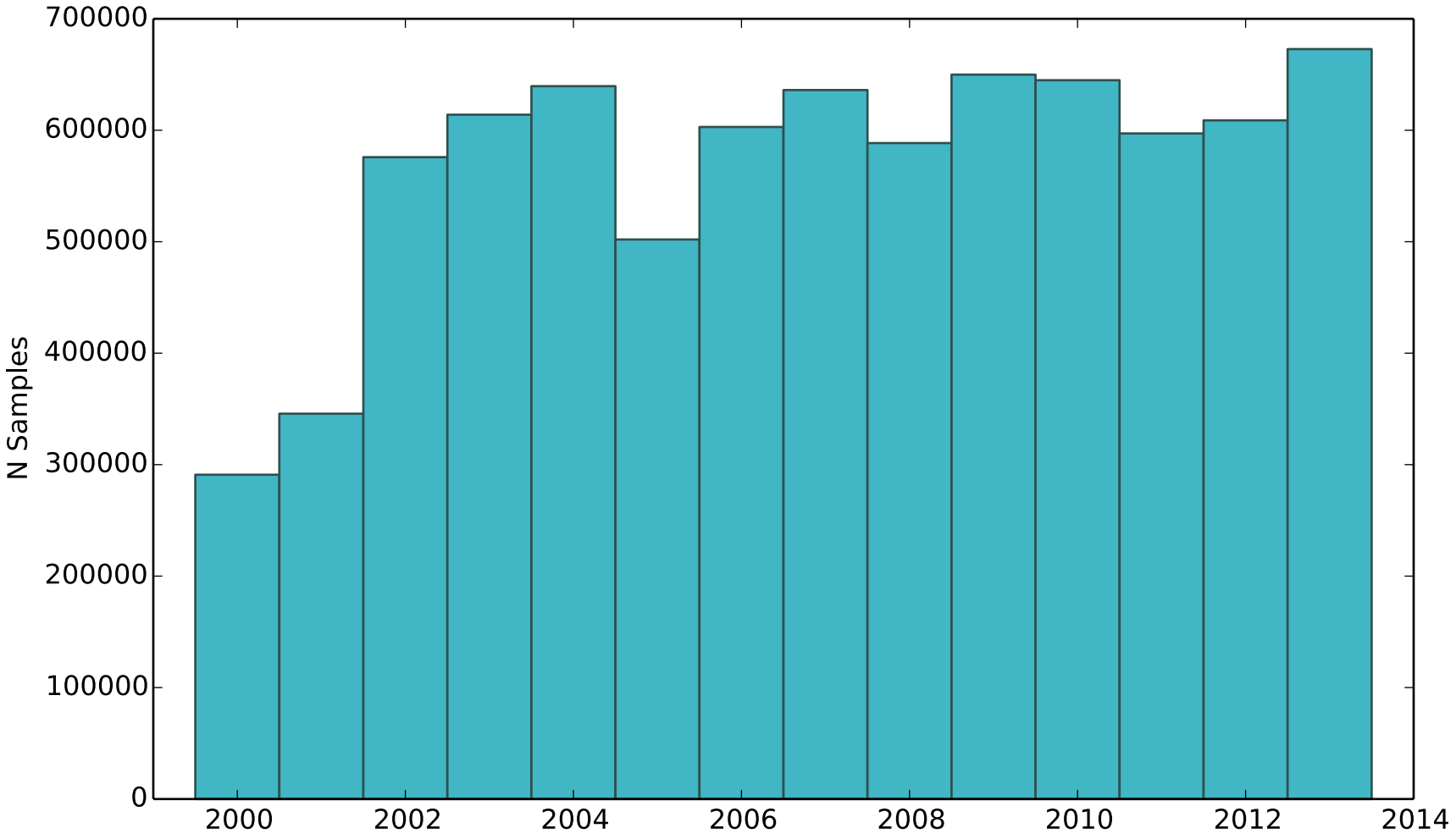


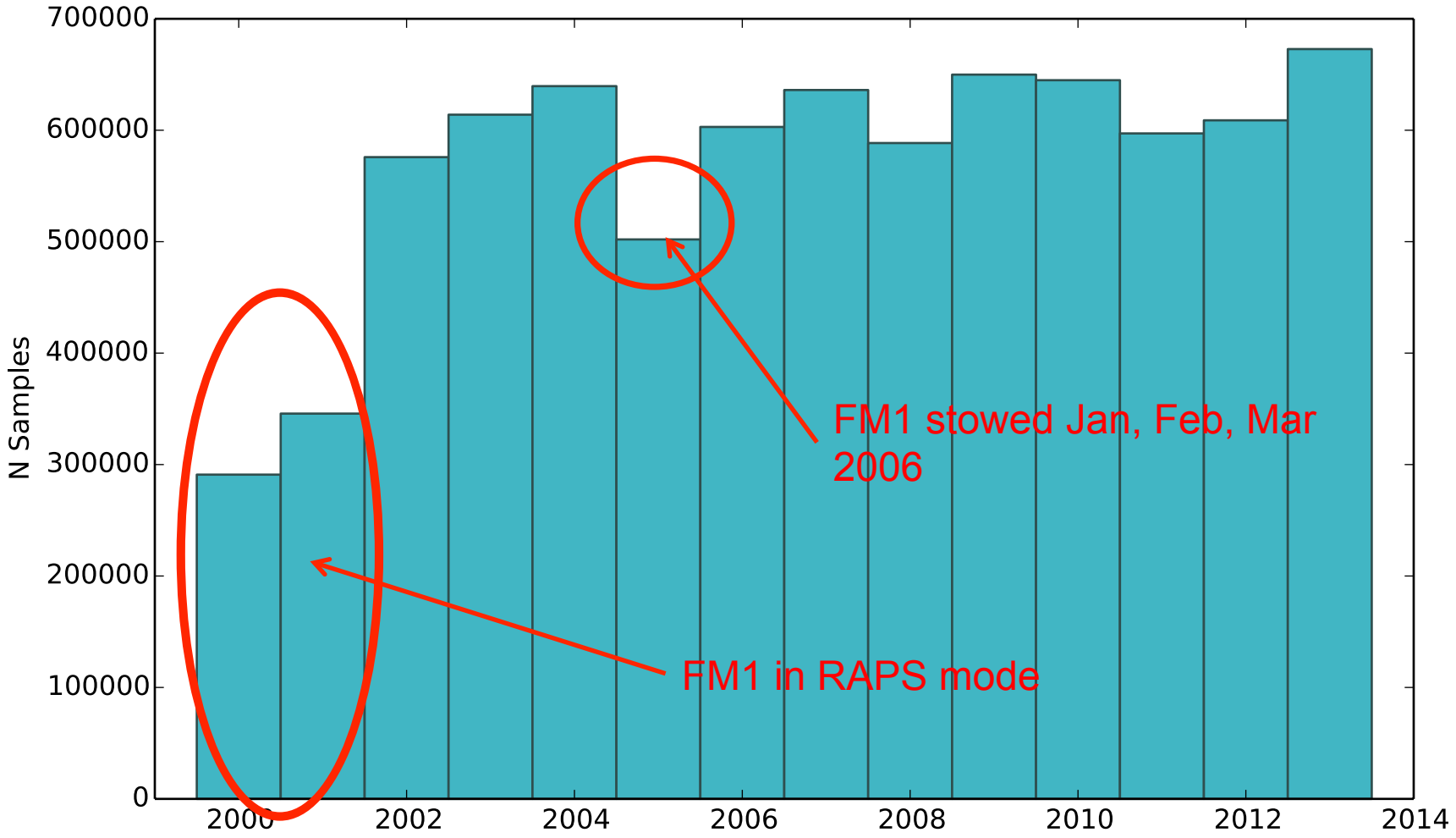
SSFM Dataset

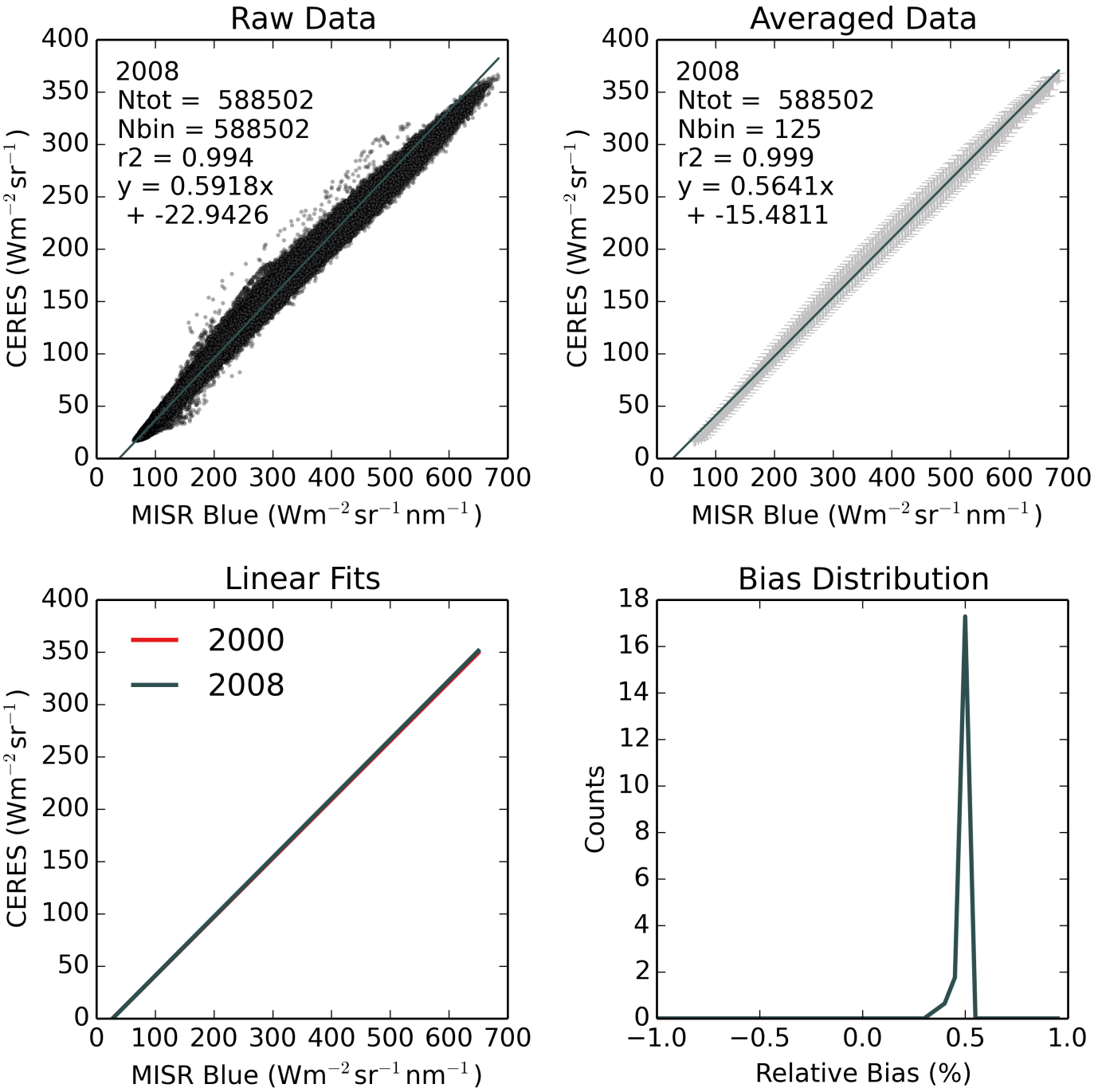
- Takes the existing SSF dataset - CERES radiance, flux and MODIS radiances, CERES team cloud information and adds the MISR radiances from the different angles.
- Narrowband radiances consist of the 4 MISR bands (446, 557, 672 and 868 nm) and 2 MODIS bands (650 and 858 nm, bands 1 and 2)
- Narrowband radiances are matched in time and space and averaged over the CERES footprint using the CERES point spread function.
- We have extended it from March 2000 to February 2014 using the CERES FM1 Edition 3A, MODIS Collections 4 and 5 and MISR Level1 Ellipsoid F03_0024 datasets.
- Processed every 16th day of data in order to get the orbit repeat cycle but limit the processing time and dataset size.
- This version is limited to CERES cross track viewing angles of <5°.


2013
80
160
240
320
400
480
560
640
720


2013
80
160
240
320
400
480
560
640
720


700000
600000
500000
400000
300000
200000
100000
0
N Samples
2000
2002
2004
2006
2008
2010
2012
2014

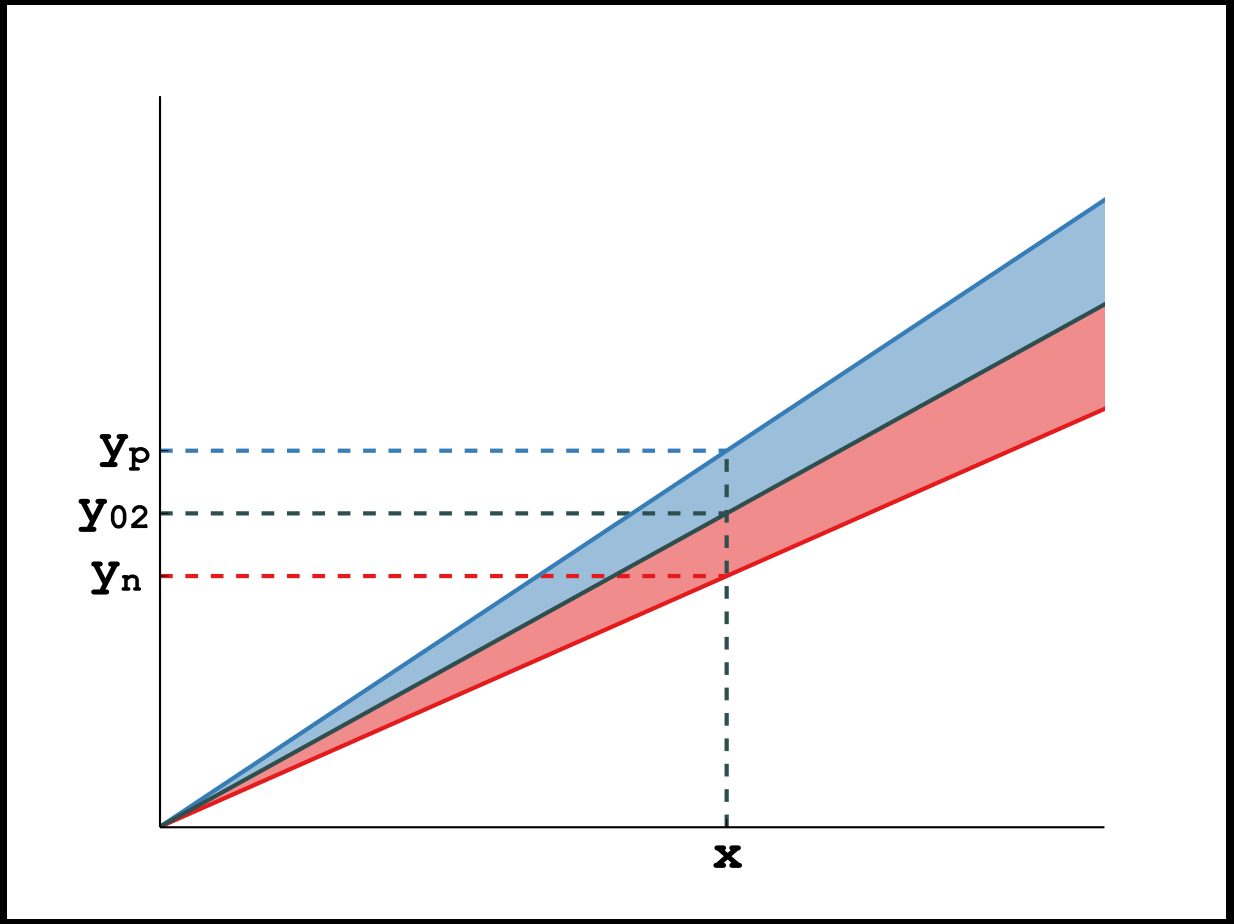

700000
600000
500000
400000
300000
200000
100000
0
N Samples
2000
2002
2004
2006
2008
2010
2012
2014
FM1 stowed Jan, Feb, Mar 2006
FM1 in RAPS mode


Raw Data
2008
Ntot = 588502
Nbin = 588502
r2 = 0.994
y = 0.5918x
+ -22.9426
CERES (Wm^{-2}sr^{-1})
MISR Blue (Wm^{-2}sr^{-1}nm^{-1})
Averaged Data
2008
Ntot = 588502
Nbin = 125
r2 = 0.999
y = 0.5641x
+ -15.4811
CERES (Wm^{-2}sr^{-1})
MISR Blue (Wm^{-2}sr^{-1}nm^{-1})
Linear Fits
2000
2008
CERES (Wm^{-2}sr^{-1})
MISR Blue (Wm^{-2}sr^{-1}nm^{-1})
Bias Distribution
Counts
Relative Bias (%)

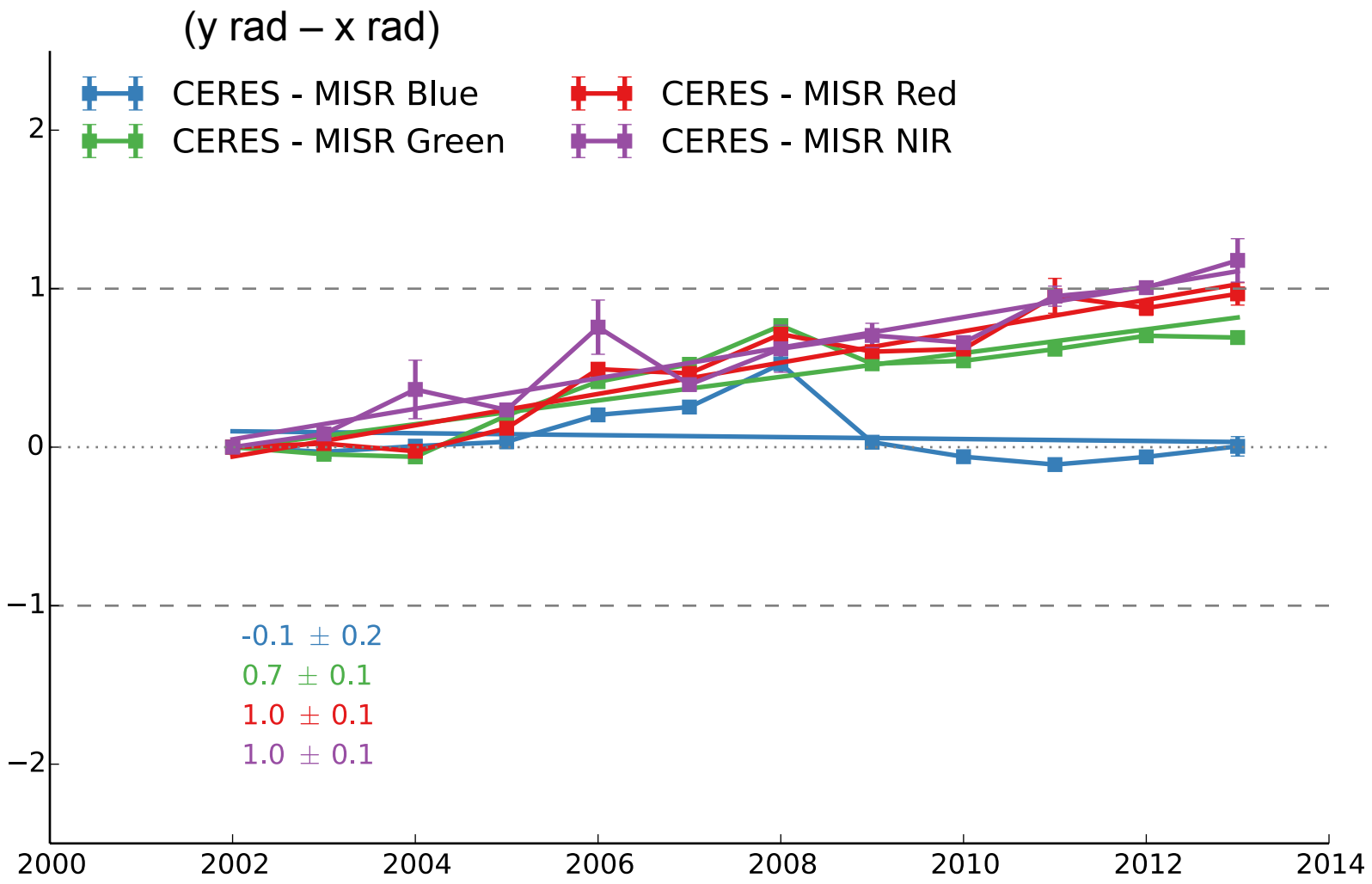
Method

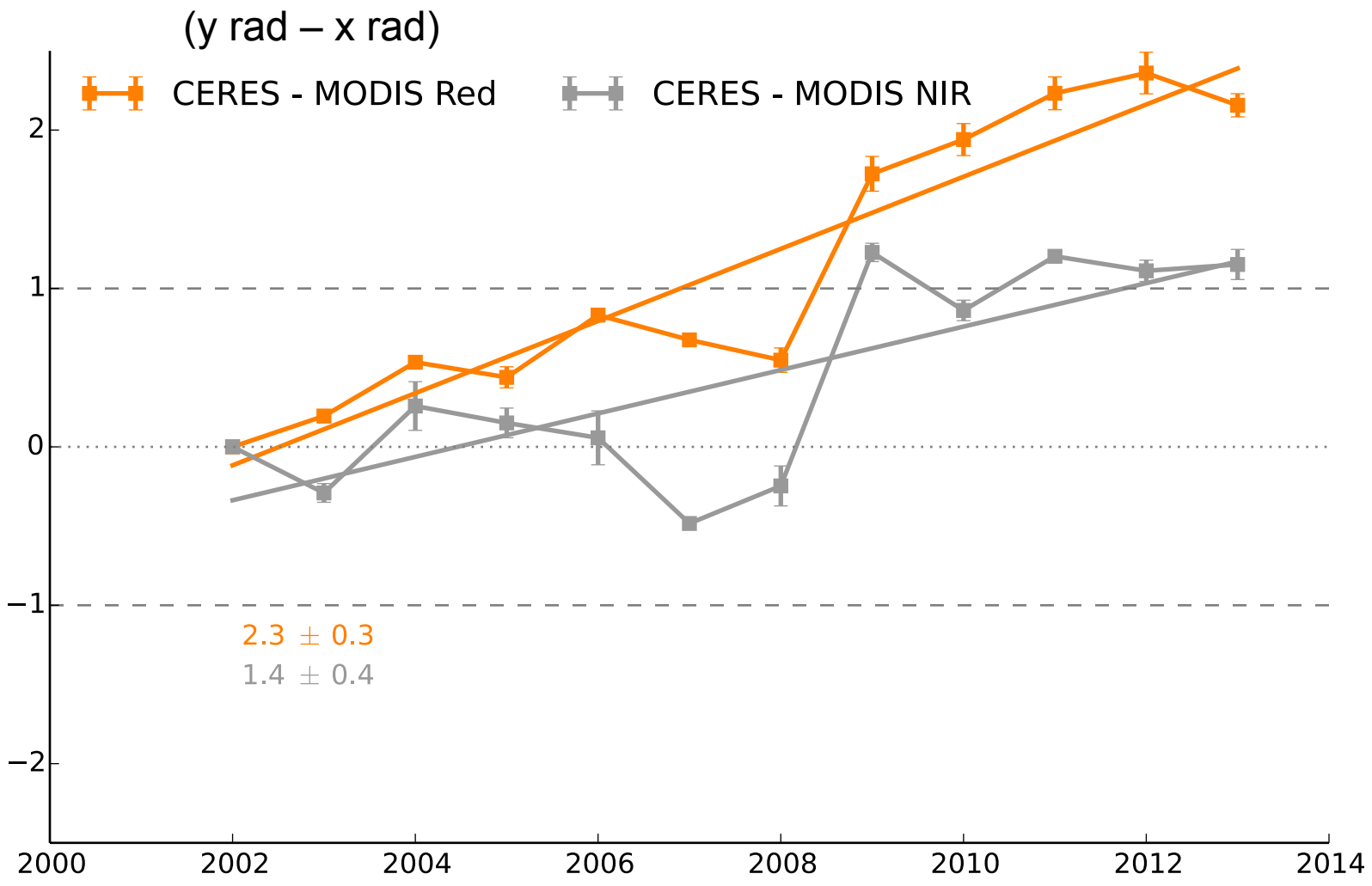
- Average the ‘y’ and ‘x’ radiance in 5 $Wm^{-2}sr^{-1}$ (3 $Wm^{-2}sr^{-1}$ if ‘x’ is a NIR band) bins of the ‘x’ radiance → $\boldsymbol{\mu}_x$, μ_y
- Perform linear regressions between $\boldsymbol{\mu}_x$ and μ_y for each year.
- Use that to estimate a ‘Y’ radiance as a function of the $\boldsymbol{\mu}_x$ radiance.
- Repeat using the regression coefficients from the reference year (2002).
- Calculate the mean relative bias → $(Y - Y_{2002})/Y_{2002}$.
- Tells us how the ‘y’ radiance has changed with respect to the ‘x’ radiance over time.

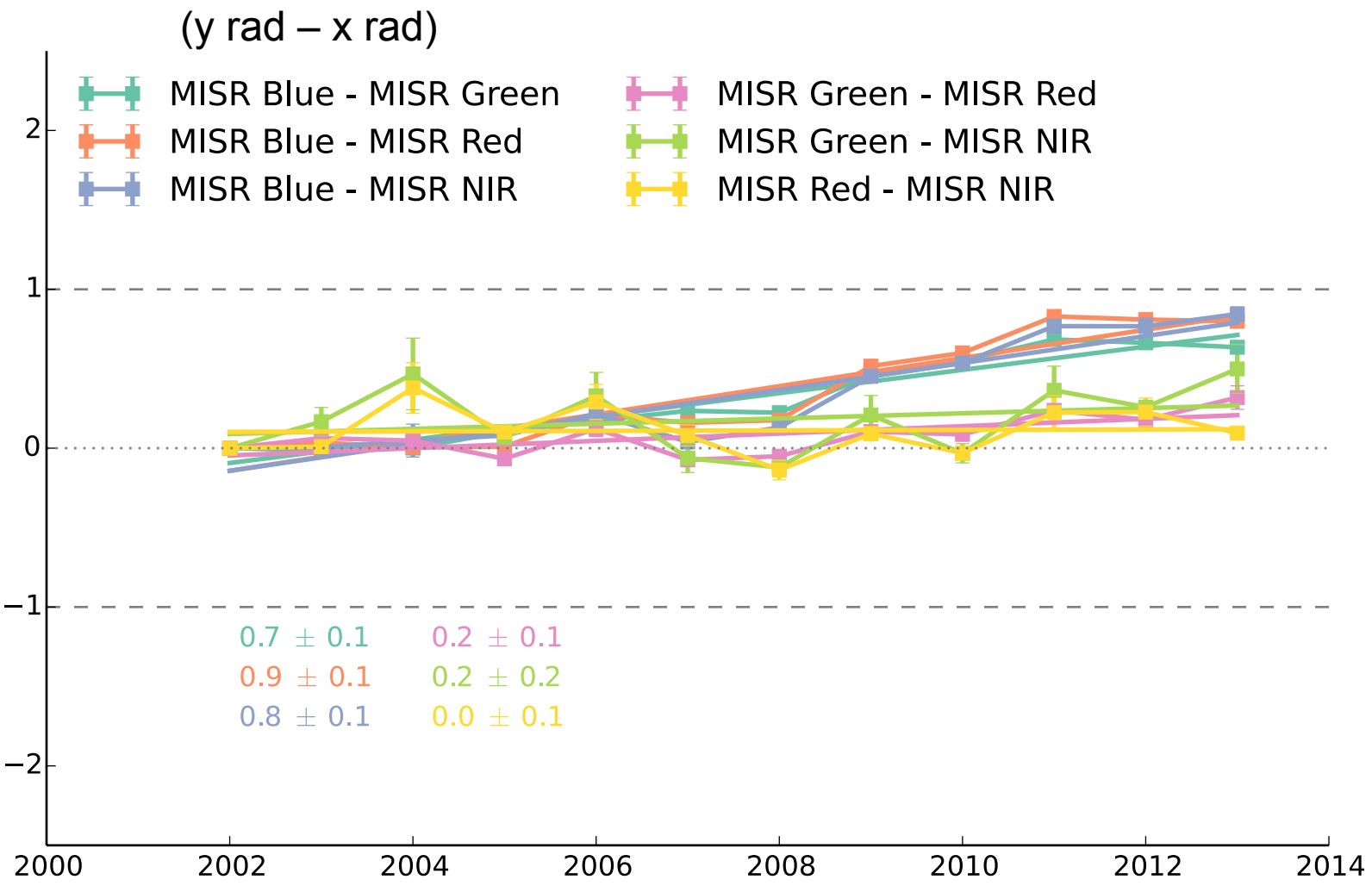
Method

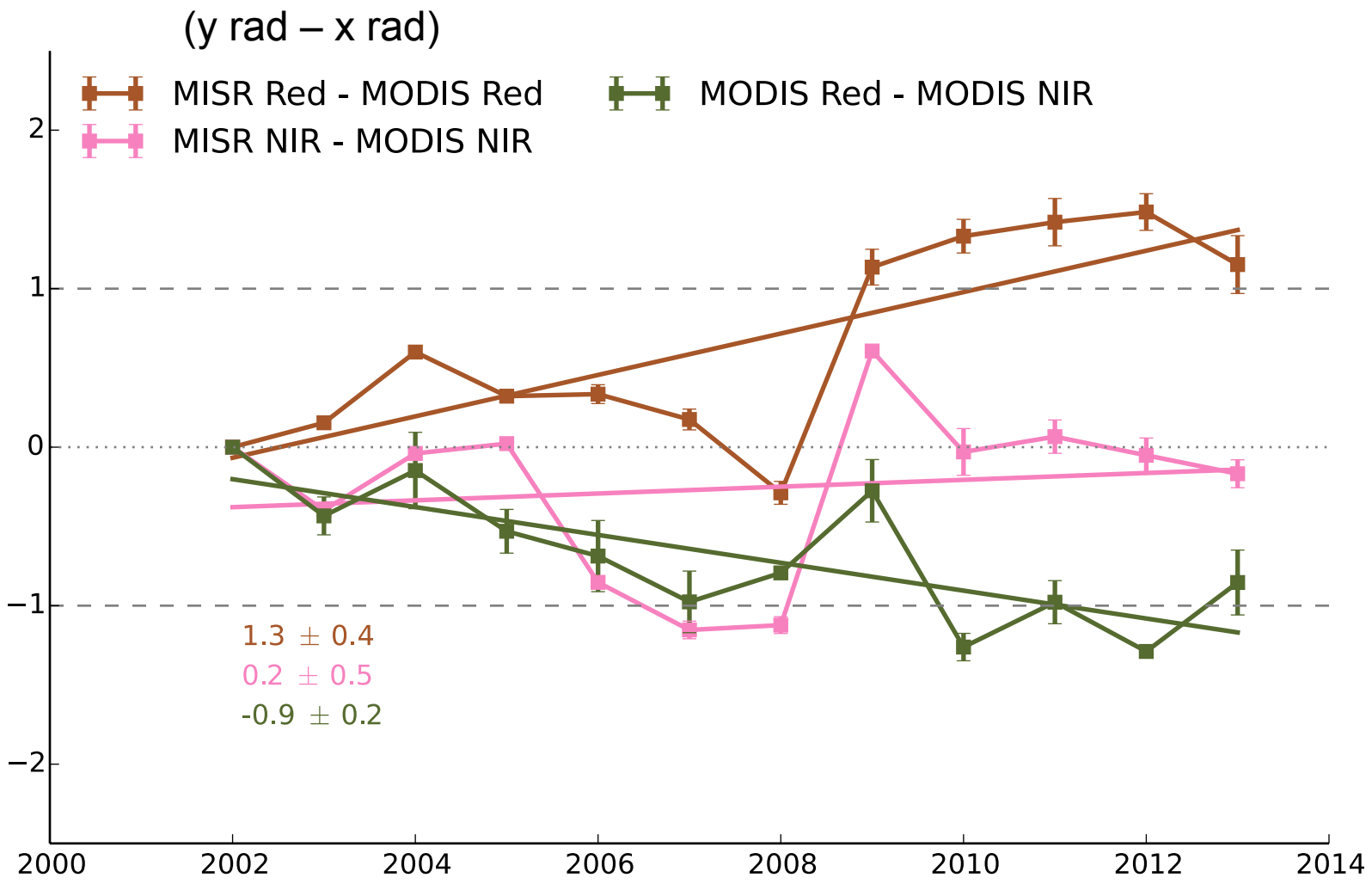


- A positive bias indicates increase in the ’y’ radiance relative to the ‘x’ radiance and negative bias indicates a decrease in the ’y’ radiance relative to the ‘x’ radiance.
- Important to note that as these are relative biases we can’t use them to say which instrument is the more stable.


(y rad – x rad)
CERES - MISR Blue
CERES - MISR Green
CERES - MISR Red
CERES - MISR NIR
2
1
0
−1
−2
2000
2002
2004
2006
2008
2010
2012
2014
-0.1 ± 0.2
0.7 ± 0.1
1.0 ± 0.1
1.0 ± 0.1


(y rad – x rad)
CERES - MODIS Red
CERES - MODIS NIR
2
1
0
−1
−2
2.3 ± 0.3
1.4 ± 0.4
2000
2002
2004
2006
2008
2010
2012
2014


(y rad – x rad)
MISR Blue - MISR Green
MISR Blue - MISR Red
MISR Blue - MISR NIR
MISR Green - MISR Red
MISR Green - MISR NIR
MISR Red - MISR NIR
2
1
0
−1
−2
0.7 ± 0.1
0.9 ± 0.1
0.8 ± 0.1
0.2 ± 0.1
0.2 ± 0.2
0.0 ± 0.1
2000
2002
2004
2006
2008
2010
2012
2014


(y rad – x rad)
MISR Red - MODIS Red
MISR NIR - MODIS NIR
MODIS Red - MODIS NIR
2
1
0
−1
−2
1.3 ± 0.4
0.2 ± 0.5
-0.9 ± 0.2
2000
2002
2004
2006
2008
2010
2012
2014

Conclusions

- Combining the CERES, MISR and MODIS products gives us a unique dataset that we can use to examine the relative stability of the instruments over time.
- Overall the trends in the relative drift between the CERES, MISR and MODIS radiances are low, less than 2.3 %/decade
- And except for MODIS they are less than 1%/decade
- The larger drifts between MODIS and CERES/MISR are mainly due to documented step changes in the calibration. We expect this to disappear in MODIS Collection 6.

CERES - MISR Blue